

What is claimed is:

1 1. A method for dyeing a cellulosic material, wherein the method comprises:

2 a) preparing a dyebath including particles of indigo pigment and a first
3 additive causing the particles of indigo pigment to become electrically charged in
4 a first polarity;

5 b) preparing the cellulosic material for dyeing by applying a second
6 additive to the cellulosic material to form a substrate on the cellulosic material
7 having an ionic charge with a polarity opposite the first polarity;

8 c) immersing the cellulosic material prepared in step b) in the dyebath
9 prepared in step a) to cause the particles of indigo pigment to be ionically
10 attracted to the substrate and retained thereon;

11 d) chemically reducing the particles of indigo retained on the substrate to
12 form a soluble leuco form entering the cellulosic material; and

13 e) oxidizing the soluble leuco form to form indigo pigment within the
14 cellulosic material.

1 2. The method of claim 1, wherein the first polarity is negative and the
2 second additive is cationic.

1 3. The method of claim 2, wherein the first additive is an anionic acrylic
2 copolymer.

1 4. The method of claim 2, wherein the second additive crosslinks with the
2 cellulosic material.

1 5. The method of claim 2, wherein the second additive is a cationic polymer
2 selected from a group consisting of polyamide and polyamine.

1 6. The method of claim 2, wherein a batch of the cellulosic material is
2 prepared for dyeing in step b) by immersion within a preparation bath composed
3 essentially of:

4 water;
5 a phosphated alcohol; and
6 a cationic polymer selected from a group consisting of polyamide and
7 polyamine.

1 7. The method of claim 6, wherein the cationic polymer has a weight of 7%
2 of the weight of the batch of cellulosic material.

1 8. The method of claim 6, wherein the batch of the cellulosic material is
2 treated in the preparation bath at a temperature of 43°C for 15 minutes.

1 9. The method of claim 2, wherein a dyebath is prepared in step a) to dye a
2 batch of the cellulosic material, and wherein the dyebath is composed essentially
3 of:

4 water;
5 indigo powder; and
6 an anionic acrylic copolymer.

1 10. The method of claim 9, wherein the indigo powder and the anionic acrylic
2 copolymer each have a weight of 2-3% of the weight of the batch of the cellulosic
3 material.

1 11. The method of claim 10, wherein
2 the dyebath is prepared in hot water for dyeing the batch of the cellulosic
3 material, and
4 a phosphated alcohol and calcium chloride are added to the dyebath.

1 12. The method of claim 2, wherein a dyebath is prepared in step a) to dye a
2 batch of cellulosic material, and wherein the dyebath is composed essentially of:
3 water;
4 indigo powder;
5 an anionic acrylic copolymer; and
6 a phthalocyanine organic pigment.

1 13. The method of claim 12, wherein
2 the indigo powder and the phthalocyanine organic pigment each have a
3 weight of 1.5% of the weight of the weight of the batch of the cellulosic material,
4 and
5 the anionic acrylic copolymer has a weight equal to 3% of the weight of
6 the batch of cellulosic material.

1 14. The method of claim 1, wherein, in step d), the particles of indigo retained
2 on the substrate are reduced by immersion in a reduction bath comprising
3 sodium hydroxide and sodium hydrosulfite.

1 15. The method of claim 14, wherein the reduction bath is composed
2 essentially of:
3 water;
4 sodium hydroxide;
5 sodium hydrosulfite;
6 a phosphated alcohol; and
7 Epsom salt.

1 16. The method of claim 14, wherein
2 sodium hydroxide is added to the reduction bath in a concentration
3 forming a pH of 11-11.5; and

4 sodium hydrosulfite is added to the reduction bath in a concentration of 6-
5 10 grams per liter of water.

1 17. The method of claim 1, wherein
2 steps b), c), and d) are performed while tumbling the cellulosic material in
3 a rotary dyeing machine,

4 a bath preparing the cellulosic material for dyeing in step b) is drained
5 from the rotary dyeing machine before the dyebath prepared in step a) is added
6 to the rotary dyeing machine, and

7 the dyebath is drained from the rotary dyeing machine before a reduction
8 bath for chemically reducing the particles of indigo is added to the rotary dyeing
9 machine.

1 18. The method of claim 17 wherein step e) is performed by air flowing
2 through the cellulosic material while tumbling the cellulosic material in the rotary
3 dyeing machine.

1 19. The method of claim 17, wherein step e) is followed by tumbling the
2 cellulosic material within the rotary dyeing machine in a finish bath including an
3 acrylic binder and a polyamide.

1 20. The method of claim 1, wherein
2 step c) is performed while the cellulosic material is moved entirely through
3 a dyebath within a jig bath vessel at least one time,

4 the jig bath vessel is shorter than the cellulosic material in a direction in
5 which the cellulosic material is moved,

6 step d) is performed while the cellulosic material is moved entirely through
7 a reduction bath within the jig bath vessel at least one time, and

8 the dyebath is drained from the jig dyeing vessel before the reduction bath
9 is added within the jig bath vessel.

1 21. The method of claim 20, wherein
2 the dyebath includes an indigo pigment and an anionic acrylic copolymer,
3 and
4 the reduction bath includes sodium hydrosulfite and sodium hydroxide.

1 22. The method of claim 20, wherein
2 step a) is performed while the cellulosic material is moved entirely through
3 a preparation bath within a pad vessel separate from the jig bath vessel,
4 the pad vessel includes a pair of rollers squeezing material from the
5 preparation bath into the cellulosic material, and
6 the pad vessel is shorter than the cellulosic material in a direction in which
7 the cellulosic material is moved.

1 23. The method of claim 22, wherein the preparation bath includes a cationic
2 polymer selected from a group including polyamide and polyamine.

1 24. The method of claim 20, wherein step e) is performed while the cellulosic
2 material is moved entirely through an oxidation bath including sodium bromate
3 within the jig bath vessel three times.

1 25. The method of claim 20, wherein
2 step e) is followed by moving the cellulosic material entirely through a
3 finish bath within the jig bath vessel at least one time;
4 the finish bath includes an acrylic binder and a polyamide.

1 26. The method of claim 1, wherein steps b), c), and d) are performed
2 simultaneously as the cellulosic material is moved simultaneously through a first
3 vessel holding a preparation bath in which step b) is performed, a second vessel
4 holding a dyebath in which step c) is performed, and a third vessel holding a

5 reduction bath in which step d) is performed.

1 27. The method of claim 26, wherein
2 the preparation bath includes a cationic polymer selected from a group
3 comprising polyamide and polyamine;
4 the dyebath includes powdered indigo pigment and an anionic acrylic
5 copolymer, and
6 the reduction bath includes sodium hydrosulfite and sodium hydroxide.

1 28. The method of claim 26, wherein the cellulosic material is dried as moves
2 between the first and second vessels and as it moves between the second and
3 third vessels.

1 29. The method of claim 26, wherein the cellulosic material is moved from the
2 third vessel through a steamer.

1 30. The method of claim 29, wherein the cellulosic material is steamed for one
2 minute within the steamer.

1 31. The method of claim 26, wherein step e) is performed within an oxidation
2 chamber through which the cellulosic material is moved as ozone is supplied to
3 the oxidation chamber.

1 32. The method of claim 26, wherein the cellulosic material is additionally
2 moved through a finish bath including an acrylic binder and polyamide within a
3 finish vessel.

1 33. The method of claim 1) additionally including, following step f), immersing
2 the cellulosic material in a finish bath including an acrylic binder and polyamide.